Karlsruher Institut für Technologie

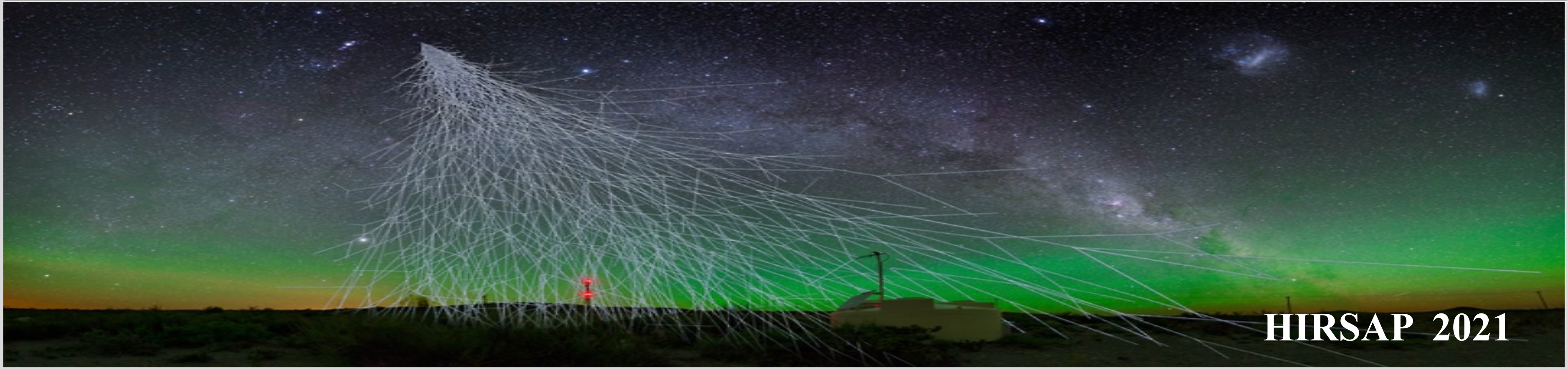
Double Doctoral degree in Astrophysics

UNSAM UNIVERSIDAD NACIONAL DE SAN MARTÍN

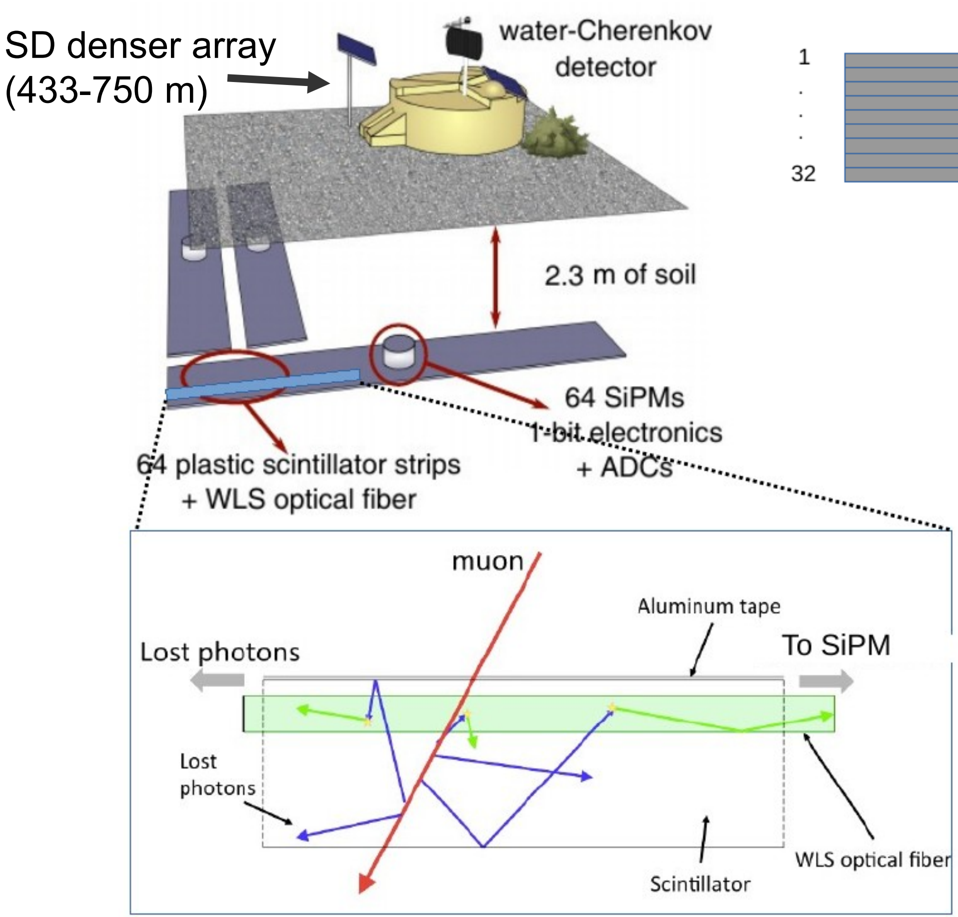
Instituto de Tecnologías en Detección y Astropartículas

Updates on the Calibration of the ADC Channel in the UMD

Marina Scornavacche



Underground Muon Detector



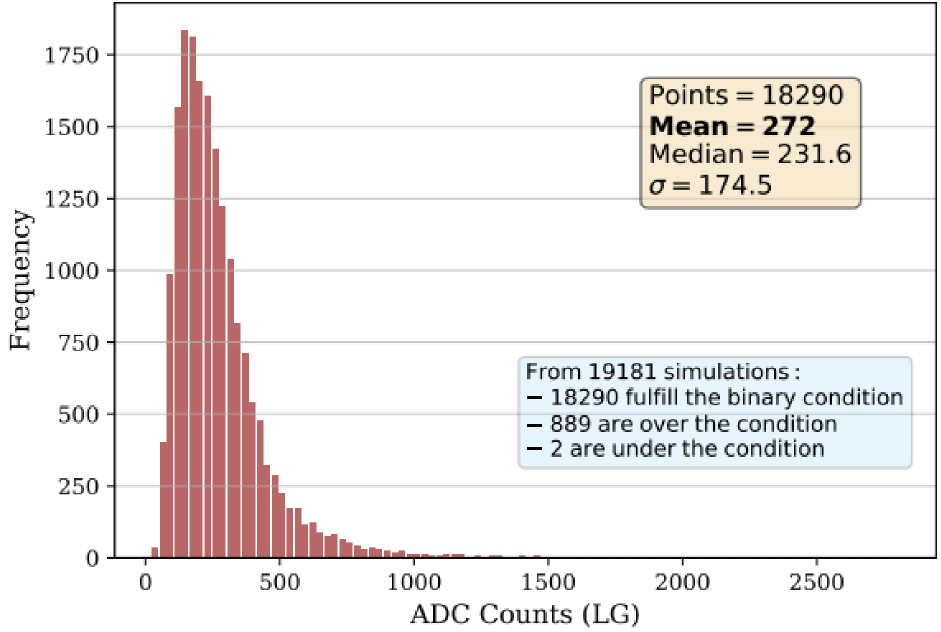
Charge Histograms (for one muon)

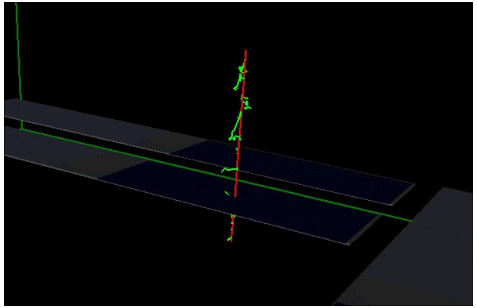
Mean Charge of the muon

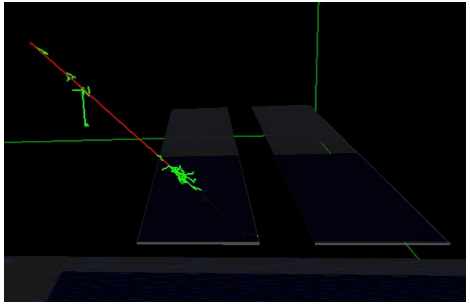
$$Number_{\mu} = \frac{Signal_{total}}{< Charge_{1\mu} >}$$

Calibration Histograms

Random simulations with *energy* and *zenith angle* following distributions of background muons, *azimuth angle* and *position of injection* (in the module) uniformly distributed







Binary Condition: Between 4 and 12 Ones on only ***one*** scintillator strip

Over the binary condition: More than one scintillator strip fulfill the criteria

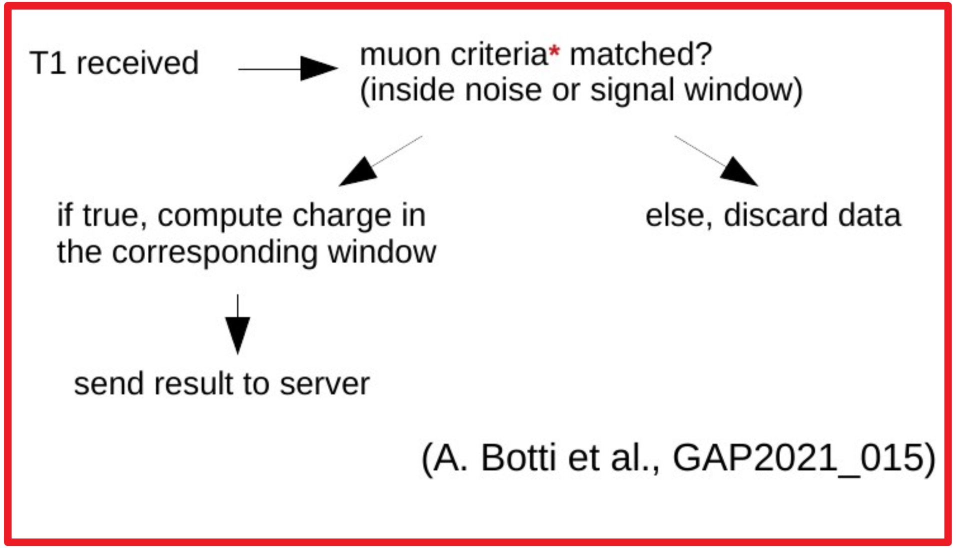
Under the binary condition: No scintillator strip fulfill the criteria

Calibration Data

- **Algorithm implemented in the electronics** to extract calibration data for the ADC Channel.

- It includes **background muon signals but also noise** coming from the optical-fiber /scintillator system.

- When a T1 is received the algorithm **looks for muons** in the binary channel **in two different windows**: one around the position of the T1 in the trace to look for background muons, and one far away from the trigger scope to obtain noise signals.

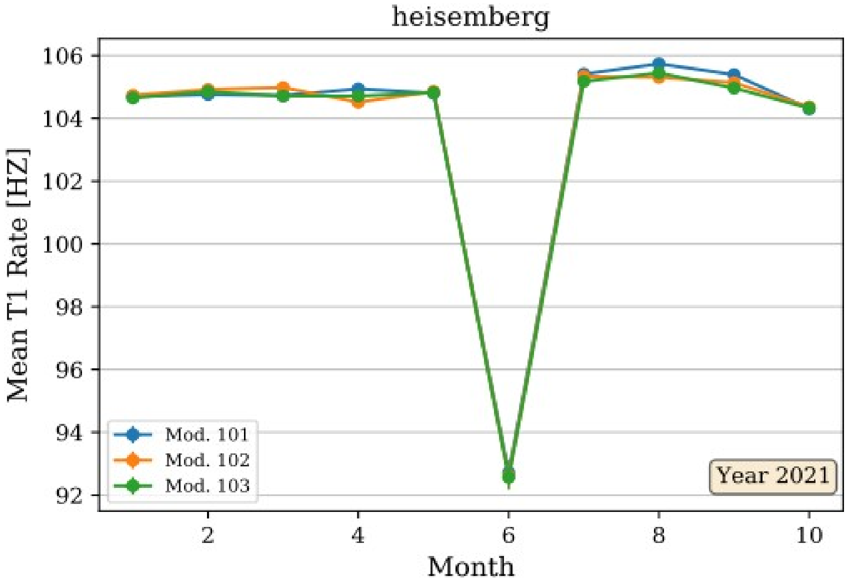


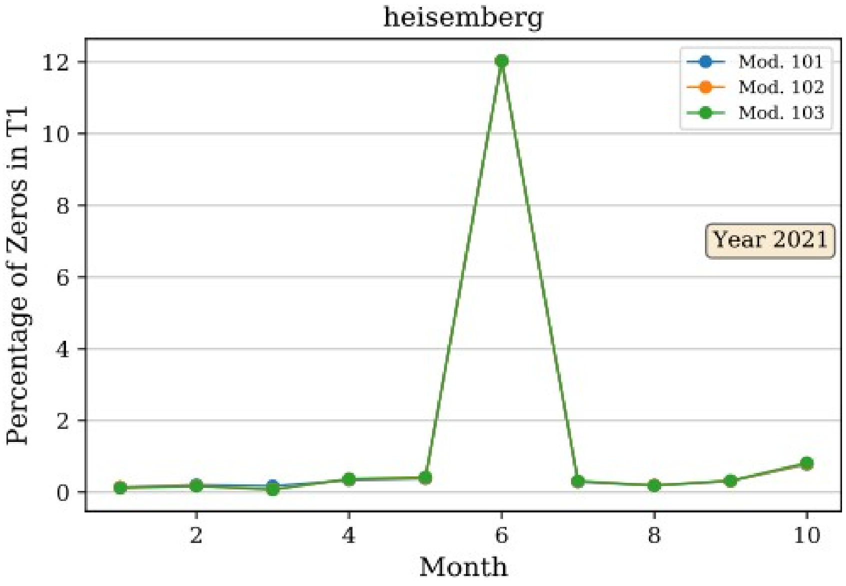
*more than four “1”s and less than twelve on only one scintillator strip

Monitoring T1 Rate

Are T1 events modulated? Could this explain the seasonal modulation of the charge on the ADCT1 files?

- One of the Hardware monitoring variables is the T1 Rate. Each T1 is sent to the UMD electronics.
- The calculation of the rate is done on a temporal basis that is asynchronous between the three modules. This can introduce fluctuations, that should be removed by the mean.

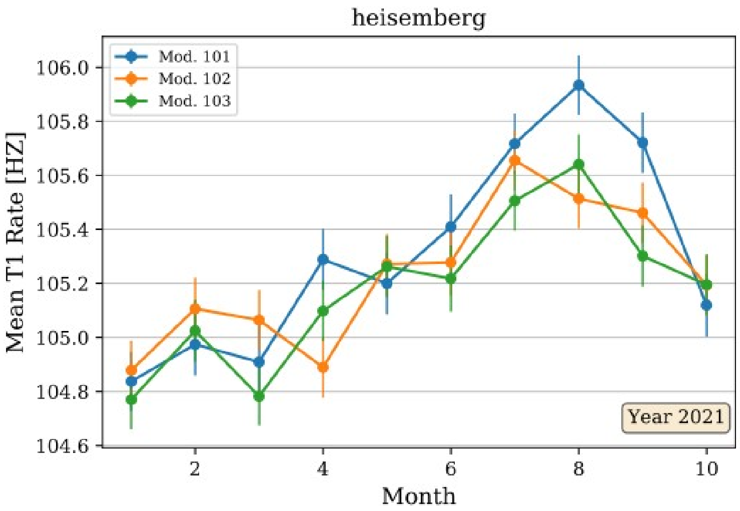




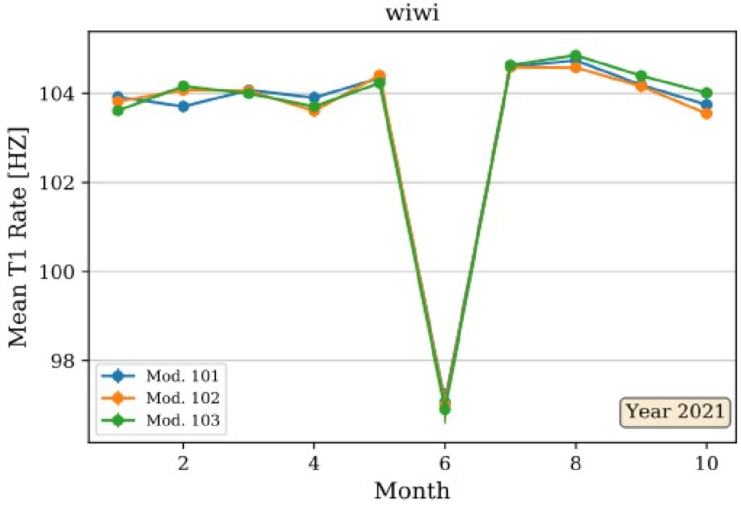
'Zeros' in the monitoring of T1 events represent a lack of communication

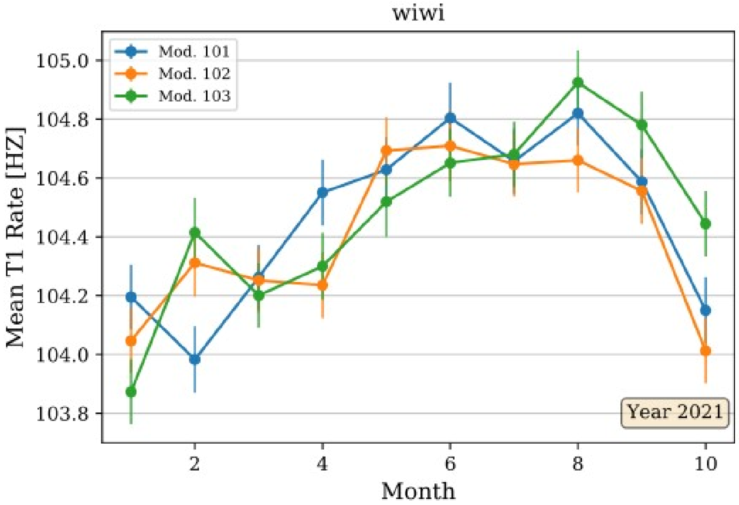
T1 Rate Study

After Cleaning the data
(removing periods with lack of communication)



The Rate of T1 events seems quite stable during 2021 (for all the stations)





Calibration in the field

What are we measuring as single muons?

1) Low energy shower that produces *(Previous Approach)*

- 1 T1 on the WCD
- 1 Background Muon on the UMD

(this "shower" does not have correlated particles that our detector can distinguish)

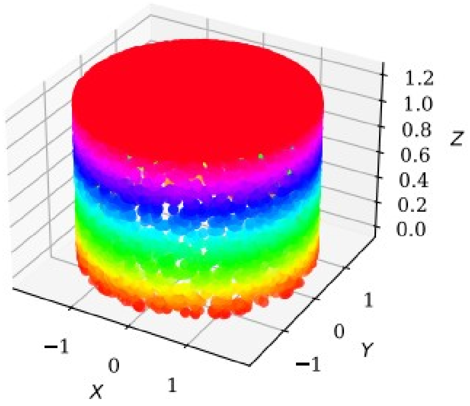
2) 1 T1 on the WCD and signal on the UMD **by the same particle. This would explain on data:**

- Mean charge higher
- Distribution of the number of events*
- Charge varying on each half of the same module*
- In showers with bigger zenith angle, events and ADCT1 are in agreement (suggesting that the ADCT1 muons are more inclined)

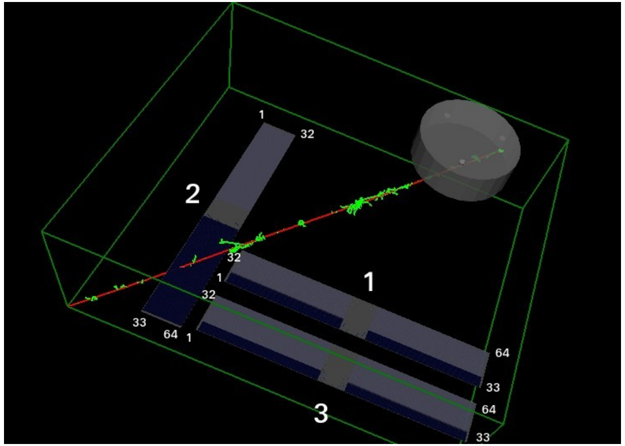
*for modules that have the same orientation with respect to the WCD

Simulating muons on WCD+UMD

Random simulations on the WCD detector, forcing the SD to Trigger (<*forcedSDTrigger*> ON at the *MdOptoElectronicSimulator*)

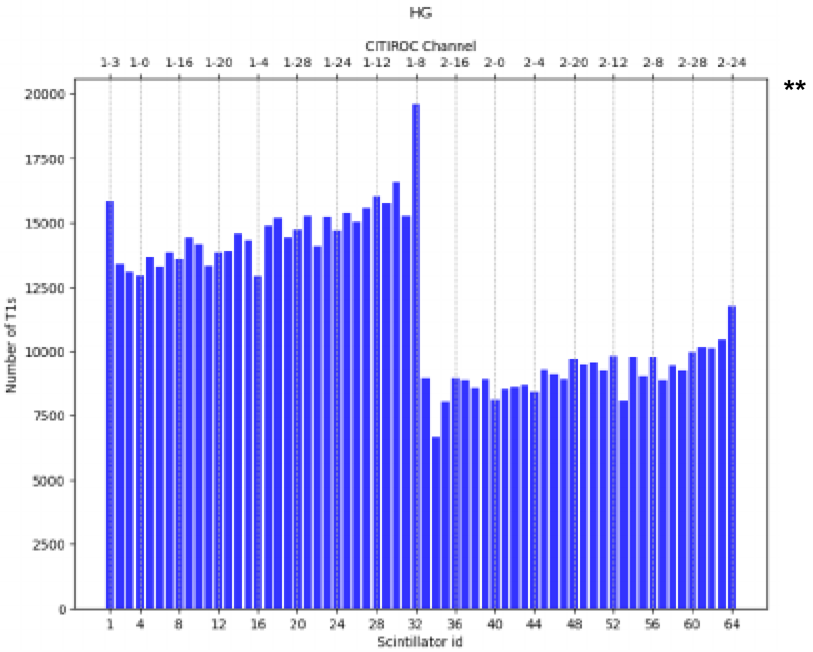


There are differences between **data (left)** and **simulation (right)** on the labeling of the modules and scintillator strips.

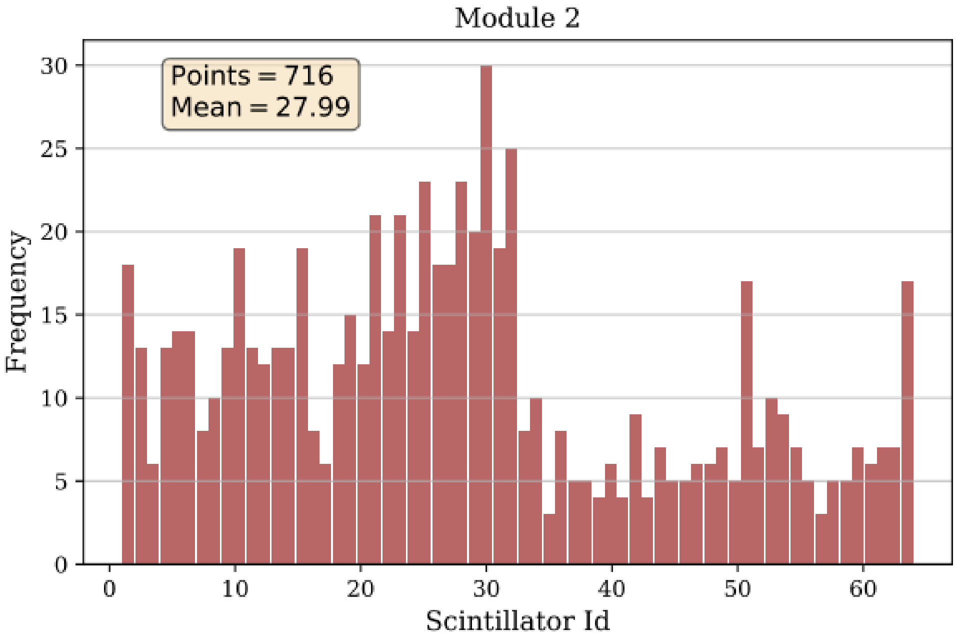


Field Data vs Simulations

**Joaquín de Jesús



m101



Simulation and data show a discrepancy on the number of events between each half of the module.
The plots for the three modules are quite in agreement.

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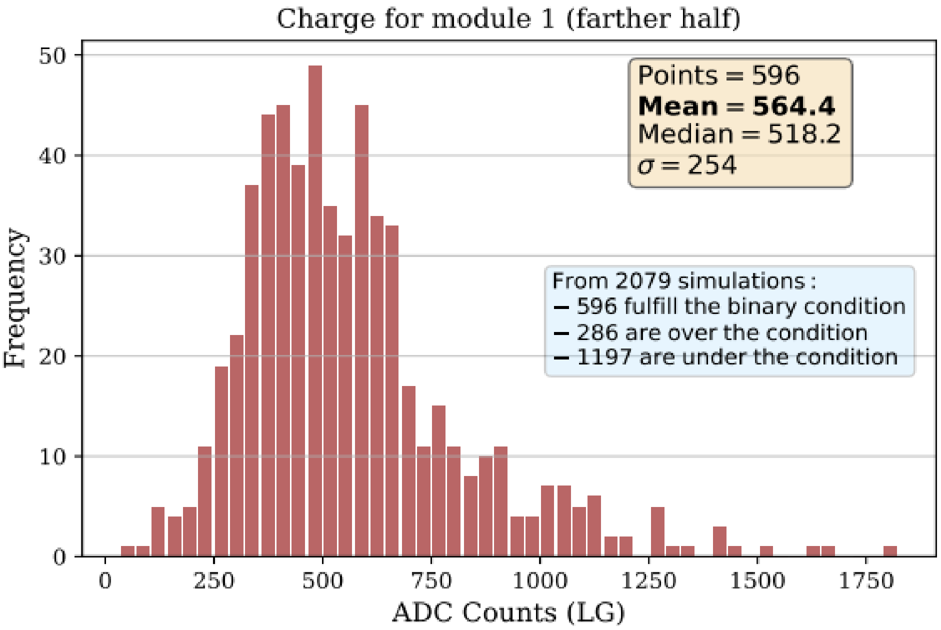
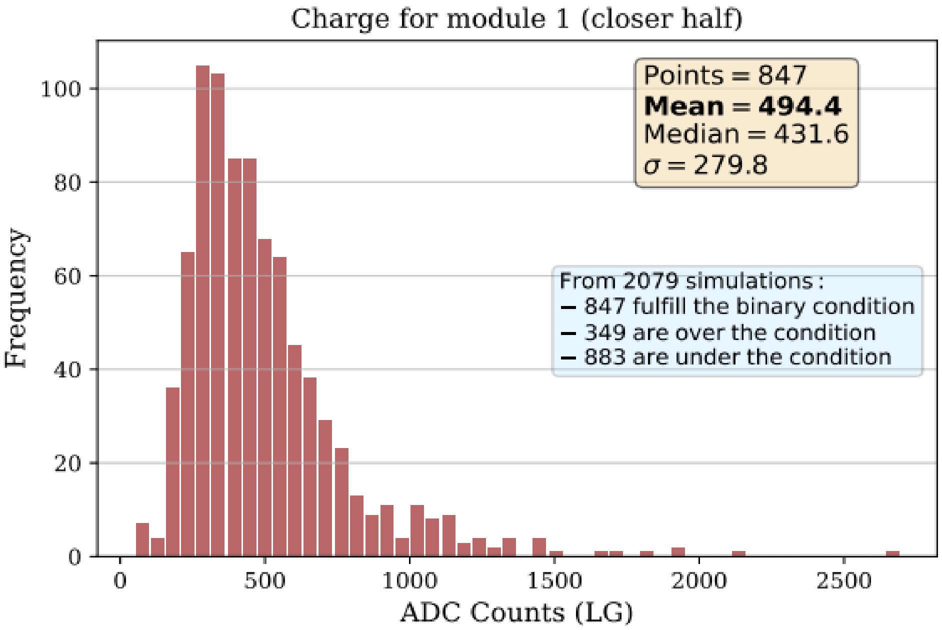
Charge for halfs on Simulations



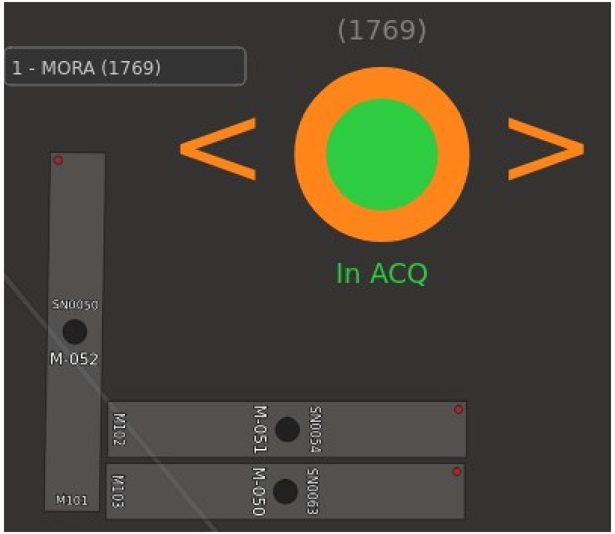


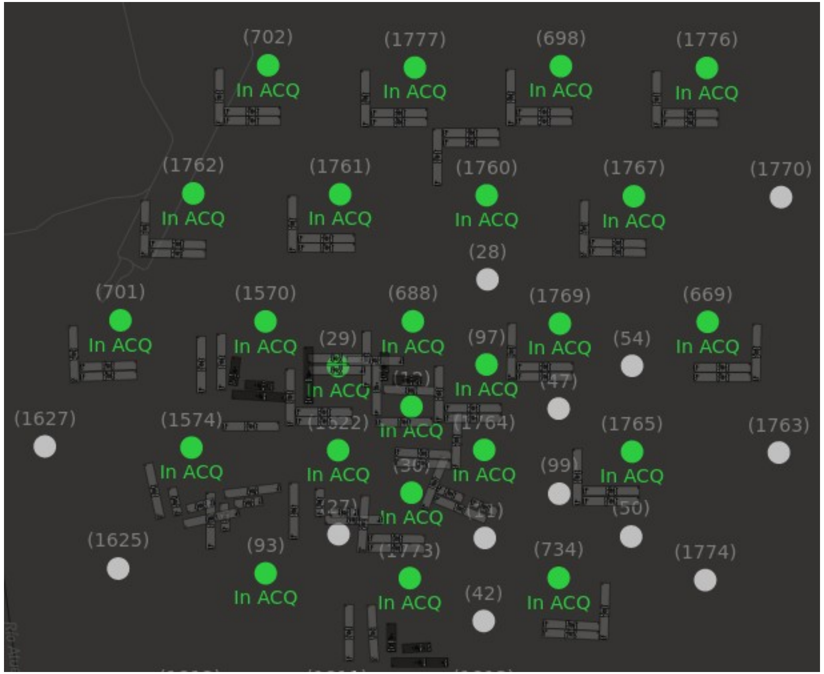
The farther away from the tank, the bigger the charge (the same happens for the other modules)

Data Study for the ADCT1

Stations which modules have the same orientation in the field:

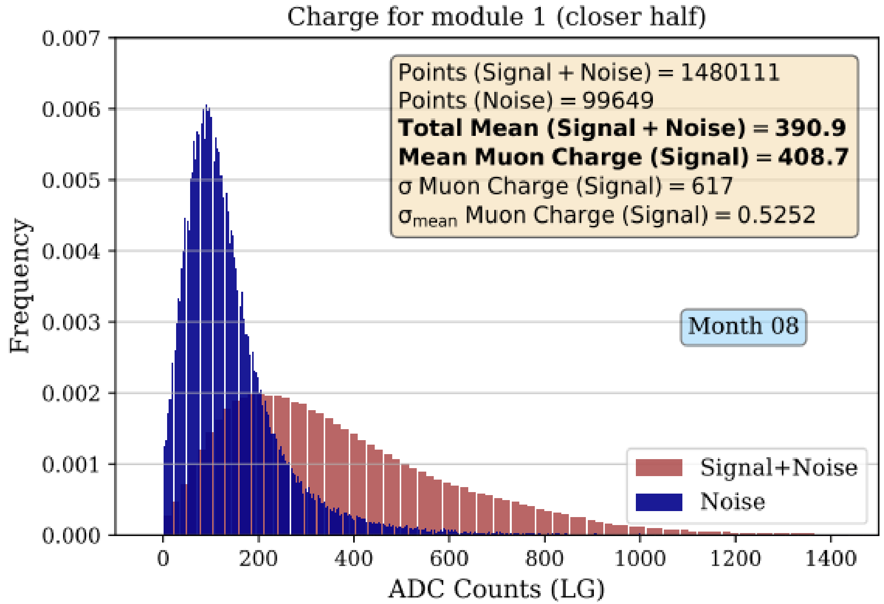
mora, casa-ronald-mza,correo-argentino, franquito, luisa, norberto-wilner, pea, peter-mazur, wiwi

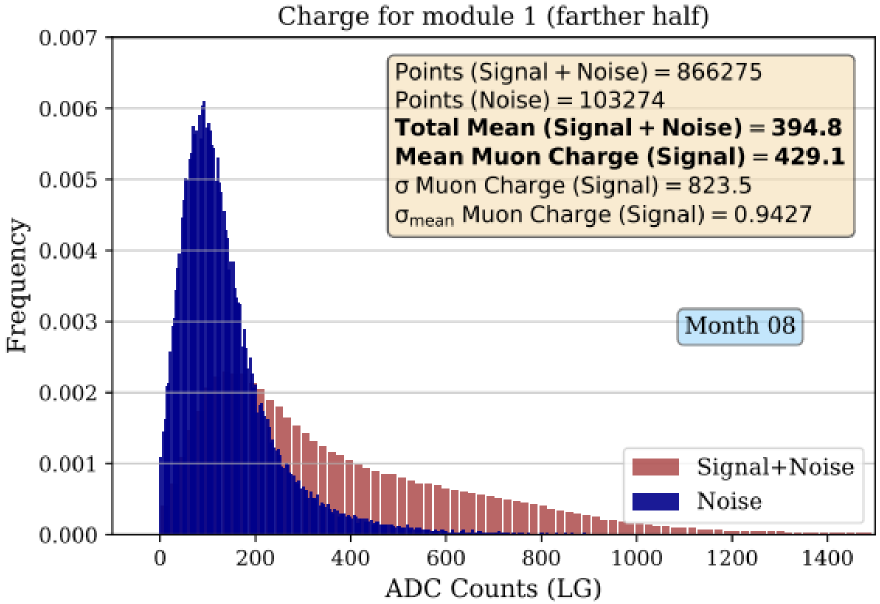




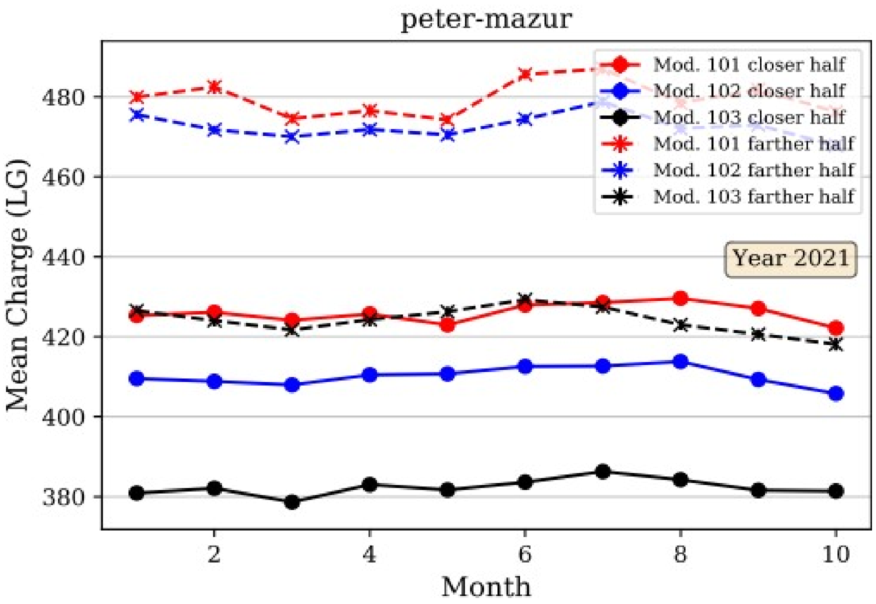
Charge for halfs on Field Data

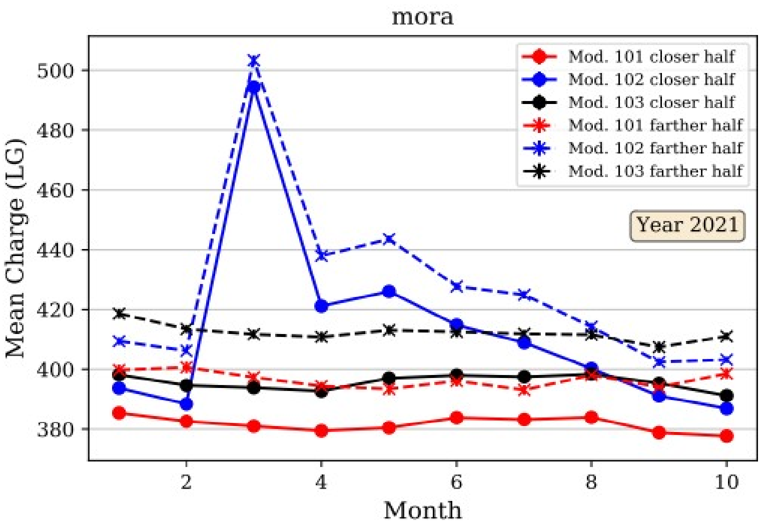
The charge is bigger for the farthest half to the WCD (in agreement with previous simulations)

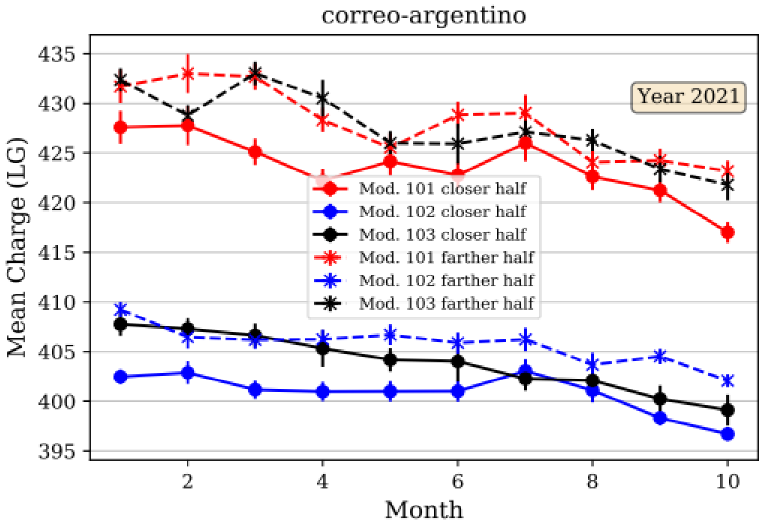




Yearly evolution of stations

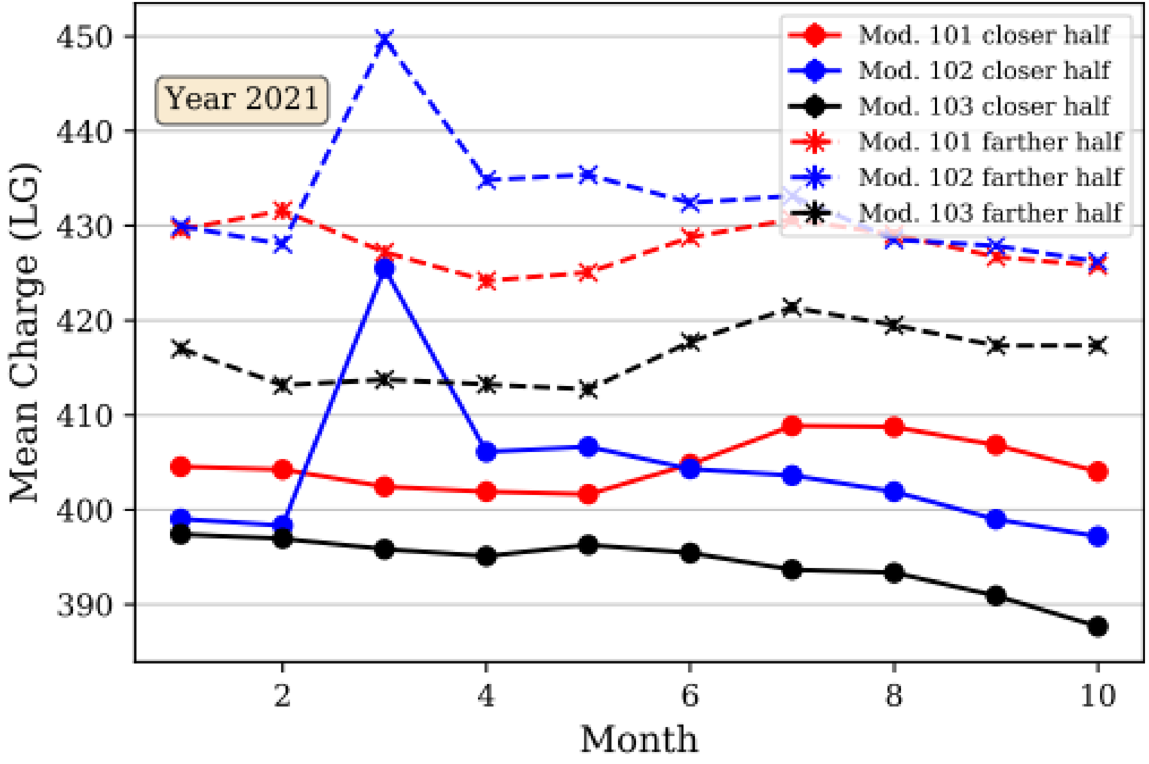






The charge is systematically bigger (during all the year) for the farthest half to the WCD.

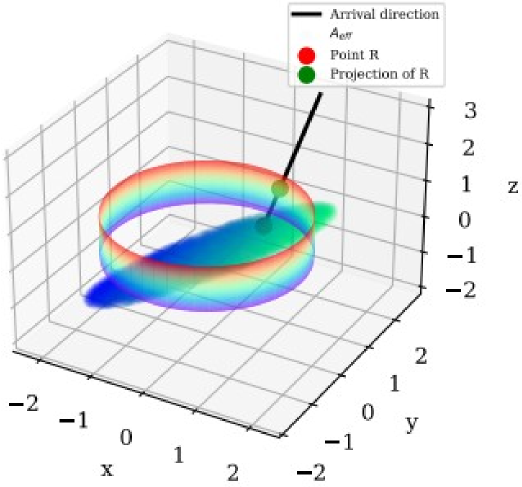
Early evolution for all the stations

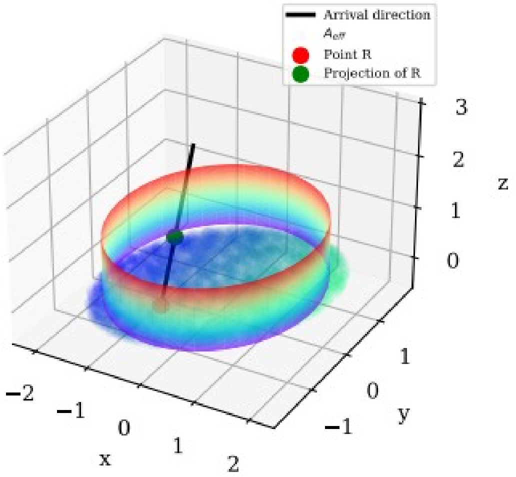


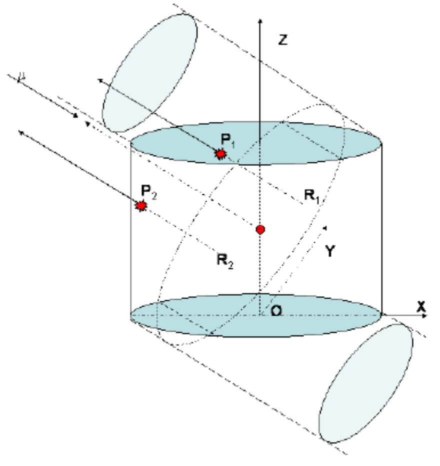
- The charge seems to be dependent on zenith angle.
- Variations between modules could be explained by the fluctuations on the electronics.

Simulation strategy

$$A_{eff}\left(\theta_{\mu}\right) = \pi R^{2}\cos\left(\theta_{\mu}\right) + 2\ \ RH\sin\left(\theta_{\mu}\right)$$







igure 4: *Effective area seen by a beam of muons with fixed direction. The two small ellipses are used to enerate hits on the surface of the stations. The point R_1 and R_2 are example of generated position on the urface which is the projected cylinder on the plane perpendicular to the arrival direction of a muon. The oint P_1 and P_2 are the projection of R_1 and R_2 back to the station surface along the opposite direction the arrival direction.*

PRELIMINARY WORK

1) Simulations are performed following the strategy of the CachedShowerRegenerator module in Offline.
2) Cuts on zenith angle and energy are imposed so that the muon can arrive to the UMD.
3) WCD is not forced to Trigger.
Problem: the new strategy generates very low statistics (~% 4) because of the Trigger condition

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Summary and future work

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Summary:

- Many characteristics of the calibration files can be explained by inclined muons.

- The trigger condition seems to generate an asymmetry in the number of events and mean charge per module. If this is the case, calculating the number of muons should take into account this effect.

- More reliable simulations will be performed but **more statistics is needed** to do any comparison between simulations and field data. With this new approach (without forcing the WCD to trigger), both WCD - UMD signals can be studied together.

- Further studies to ensure the agreement of simulations with field data is undergoing.

Future work:

Reconstruction Technique: Combine **both binary and ADC channel** into a more accurate estimate of the number of muons by using detailed statistical models of both acquisition processes.